CONCRETEBETON

CEMENT & CONCRETE SA

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Concrete slipform pavement technology
Reinforced aerated autoclaved concrete planks
CCSA's concrete carbon model

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Creating Concrete Possibilities

AfriSam

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COVER: *Concrete slipform pavement construction in progress. Photograph by Dr Peter Taylor.*

SIRI and ALEXA have never done the ACT, nor have they ever prepared a concrete mix design or been on a construction site – why do we believe that AI or the world wide web can give us all the technical answers we need?.

This issue of Concrete Beton is packed with technical content to add and expand the readers' knowledge of sound concrete theory and practice.

Following from a CONCRETEFiX presented by Prof. Chris Goodier, Loughborough University, UK in 2023, Edwin Trout Executive Officer, ICT has contributed an update on the ICT Technical Note titled "The use and condition of Reinforced Aerated Autoclaved Concrete planks" (p.10.)

The technical article on p.14 explores the considerable potential for cementitious alternatives like fly ash (FA) and ground granulated blastfurnace slag (GGBS) to help reduce the cement industry's carbon impact.

We obtained permission to reprint an article by Dr Peter Taylor Director of the National Concrete Pavement Technology Center at Iowa State University on concrete slipform pavement technology (p.8). The article reviews the development of concrete pavement construction systems over the last 80 years and looks forward to what may be expected in the near future.

Iconic Concrete looks at the Three Gorges Dam in China (p.18). Sadly, our previous contributor, Jan de Beer, who has been writing these features for many years, has retired due to ill health. We wish him a full recovery. We are fortunate to have David Poggiolini on board to keep us spellbound with future features on more iconic concrete structures form around the world.

Read about CCSA's model which provides a reliable method of determining concrete CO_2 footprint to facilitate the design of concrete mixes with a smaller carbon footprint on p.20.

The potential impact of climate change on the durability and longevity of cement structures is unpacked in the article on p.24.

Concrete Beton remains an authoritative source of information for those who are serious about remaining informed and current with the latest technology on cement and concrete. Enjoy the read.

Concrete wishes

Hanlie

Hanlie Turner, Editor

OUR VISION
To be the unified voice of the cement and concrete industry in South Africa, defending and promoting the industry, driving growth and delivering shared value.

OUR MISSION
To create long term shared value and industry growth in South Africa. We do this by driving collaboration, skills development, innovation and the highest standards in sustainable cement and concrete materials and products.

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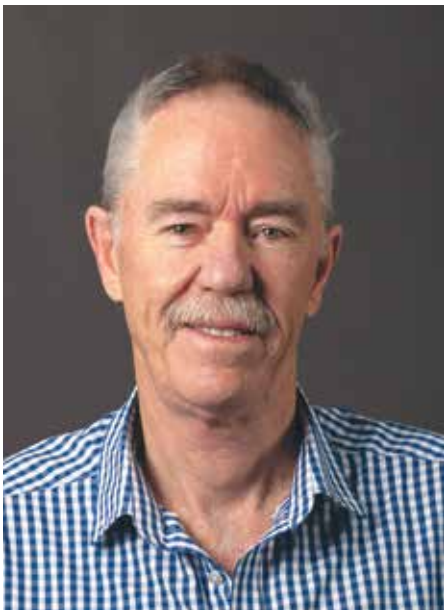
Cement & Concrete SA's recent roadshow, Concrete Working for Water, emphasised the vital role that concrete plays in the storage, supply, treatment, and consumption of both potable and industrial water.



It is often said that concrete is the second most used substance in the world, and the most widely used building material. Water however takes the place of honour as the most widely used /consumed substance on earth. It is thus only fitting that this symposium should look at these two substances in relation to each other. This roadshow has produced extremely positive feedback from many delegates about the content, the presentations, and the quality of the presenters.

CCSA, as the official body and united platform for the cement and concrete industry in South Africa, is proud to host the conversations and disseminate the information to strengthen the concrete value chain in critical areas of infrastructure.

Monthly initiatives such as CONCRETEFiX virtual webinars, the biennial ConPaveStruc and YCRETS symposia and Fulton Awards to honour excellence in concrete, all contribute to the extensive value add to the concrete fraternity. At a regional level, the Western Cape, KZN and Gauteng Branch Committees, driven entirely by volunteers for the love of concrete, arrange events specifically to involve our members of a particular geographical area with site visits, technical meetings, social events, and interactions with the tertiary institutions in that area.

Much has been published regarding CCSA's involvement with government and other statutory bodies to ensure that there is one unified voice to drive the industry's protection of end-users against non-compliant cements that do not meet the standards, as well as rogue suppliers who have no regard for the quality of a product or best practices in terms of mix proportions and site practices.

CCSA's continued involvement with SABS ensures that cement and concrete, and all its constituent materials and practices are adequately and correctly represented in the national standards and test methods.

Our representation on various Government Project Steering Committees and the Minerals Council address issues pertaining to cement and concrete legislation, the environment, health and safety, responsible use and management of resources, (both natural and human) and sound practices in South African standards.

I have personally been involved with this body for 40 years and I, like many in our industry, respect and uphold the unbiased, non-commercial and professional value CCSA adds to all its members.

Best regards
Bryan Perrie, CEO

2024 Fulton Awards judging in full swing.

Hard times endure for construction industry

While there was once again a theoretical commitment by government to spend more on infrastructure, the recent Budget Speech offered little to boost confidence in how structural impediments to growth would be removed.

Speaking at AfriSam's Annual Budget Breakdown event in Johannesburg, Econometrix Chief Economist Dr Azar Jammine highlighted the demanding conditions in construction, civil engineering and building. Celebrating its 90th year in 2024, AfriSam brings together its various stakeholders each year for this presentation, recognising their vital contribution to the business.

AfriSam Sales and Marketing executive Richard Tomes acknowledged that the construction industry would remain under pressure, but said AfriSam's 90 years was an inspiring achievement built on the sector's resilience over the years.

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Dr Jammine noted that the Budget Speech was taking place in the context of continued low growth, and that revenue collections were down on last year's budget. While the Treasury had managed to engineer reduced budget deficits and public debt, this was the result of expedient once-off measures, such as the exploitation of the Gold and Foreign Exchange Contingency Reserve Account (GFECRA).

A key challenge that remained was the level of gross fixed capital formation, he emphasised. After declines in capital formation from 2013 to 2020, however, there has been an improvement.

PRIVATE SECTOR INVESTMENT

"Fixed capital formation has declined from a peak of 24 % of GDP in 2008 – just before the FIFA World Cup event – to below 13 % in 2021," he said. He pointed out that, in emerging markets like South Africa, ideally around 25 to 30 % of GDP should be invested in capital projects in order to maintain as well as infrastructure growth and ultimately reduce unemployment levels.

"The good news is that capital investment has recovered somewhat to over 15 %, so we have started moving in the right direction," he said. "This factor has been at the heart of South Africa's economic decline – with much of the cause being related to corruption and crime."

The private sector was behind most of this capital investment, as government investment had been low, he said. There was a "massive decline" in investment by state-owned enterprises – which have "run out of money to do much investing".

DECLINE IN CONSTRUCTION

Most of the private sector investment was in machinery and equipment, he pointed out. While this meant that South Africa was keeping up with technology, there was no similar investment in construction, civil engineering and building. At a current index level of 80, the sector had dropped from an index level of 145 in 2013 – a decline of 40 to 45 % over the past decade.

"This is horrific, and there is little sign of it recovering," he said. There had been a slight recovery in residential building between 2020 and 2022, as the Covid-19 pandemic caused home-owners to invest in their properties to accommodate working at home – but that 'boom' has faded. On the non-residential side, the volume of building plans passed has declined by two-thirds.

"The big loser is in commercial space, which has fallen by 80 % in terms of plans passed," he said. Retail sales at builders' merchants has reflected this sluggishness, coming in as the weakest segment of the retail sector.

REGIONAL ASPECTS

He noted that there was a regional dimension to the performance of the building sector, with the Western Cape having surpassed South Africa's traditional economic powerhouse of Gauteng in recent years.

"This is clearly linked to a wave of 'semi-gration' of many South African professionals," he said. There has, however, been a slight uptick in the building plans passed in Gauteng – perhaps the sign of a revival. The number of building plans passed in KwaZulu-Natal remained depressed.

SECTOR JOBS DOWN

The state of the construction sector is also reflected in its falling job numbers, he said. From being one of the sectors with the highest levels of employment, the level of employment in construction – as a percentage of the economy's total employment – has dropped from over 6,5 % [in 2017 to 2018] to about 4,5 % of the total national workforce. "From 2019 to 2023, employment in construction is down 40 %," he pointed out. "No other sector in the economy has been performing as badly."

Dr Jammine reiterated that crime was also a central factor in holding back progress in the construction industry, and was encouraged by the Business Leadership South Africa's workstreams to work with government on energy, transport and crime.

"I don't need to remind members of this audience of the debilitating effect that the construction mafia are having," said Dr Jammine. "I only hope that government will listen to the private sector and involve them more in finding the solutions."

LOADSHEDDING, LOGISTICS

He highlighted that high levels of Eskom loadshedding was a key factor behind the economy's poor performance, alongside the increasingly unreliable rail network. A silver lining of the energy crisis was that South Africa had seen an "enormous uptake" of solar energy generation among businesses and private households, he said, with some 6,000 MW is being generated by photovoltaic installations. This trend was creating is a "huge opportunity" for the cement sector – and other industries serving construction – to produce more renewable energy, he explained, but "there seems to be a lack of commitment by some in government to go that route".

With regard to transport infrastructure, he noted that there had been a considerable decline in rail capacity, with much of these goods and materials now transported by road. This had caused serious bottlenecks, especially at the country's ports – reducing the volume of seaborne cargo passing through South African ports by 30 to 40 % over the past few years.

"For instance, the tonnages exported through Richards Bay Coal Terminal is down from 76 million tons in 2017 to just 47 million tons in 2023," he says. Fortunately, there has been some recovery, which he believes is related to the change of management at Transnet – who are coming to grips "a little better" with the problems they face. Mining output was now lower than it was in 2010.

"With manufacturing, it is virtually the same story," he said. "The industrial heartland of the country has taken a massive knock, contradicting the government's policy of trying to promote re-industrialisation – it is not happening."

He pointed out that, while the retail sector sales were about 50 % higher thanthey were a decade ago, this was not to be celebrated. "This is not a good story," he explained. "We are consuming more and more, but we are not producing enough – so will become more dependent on imports."

STILL CREATING CONCRETE POSSIBILITIES

Despite the tough times, Tomes believed that the construction industry – like AfriSam – would come through this challenging period with its proven resilience.

"We will continue to create concrete possibilities for our beautiful country for many years to come," he said. "As AfriSam, we look forward to being the construction sector's partner of choice through thick and thin." **CB**

Concrete slipform pavement technology

Peter Taylor, CP Technology Center, Iowa State University

B&W historical pic: Courtesy Iowa Department of Transportation.

INTRODUCTION

Transportation is the backbone of our current lifestyle. Goods, food, water, and medicines are all hauled significant distances to reach most of the people in our county. The necessity for effective transportation is clearly evident when natural disasters occur, and transportation infrastructure fails. It does not take long for people to start getting desperate for the basics for survival. We also travel for leisure, business and to catch up with family on weekends and holidays. An integral part of this system is the 4-million-mile U.S. public roadway network, with much of personal and freight transportation occurring by car or truck. Pavements that facilitate this system are therefore critical to the well-being of the nation.

What is needed then, is technologies that allow construction and maintenance of pavements that are sustainable, reliable, long lasting and cost effective. This article reviews the development of concrete pavement construction systems over the last 80 years, and looks forward to what may be expected in the near future.

THE PAST

Part of the reason the Roman Empire dominated the known world at the time, was because they invested significant resources into constructing roadways which facilitated the rapid movement of their goods, people, couriers, and armed forces across their territory. Roman roads generally comprised several layers of base materials, capped with rocks as the surface. Smoothness by modern standards was ugly, but the roads were serviceable for the traffic at the time, and very durable. Crossfalls, drainage systems, and curbs, similar to those used today, all contributed to their functionality and durability.

Likewise, the Eisenhower highway system opened up the US to rapid civilian transportation in the 1960's. The trip between Washington DC and San Francisco took 62 days in 1919, while it can be done in 41 hours (at the speed limit) today. Before surfaces were paved, many rural roadways were dusty when dry and muddy when wet, making travel slow and sometimes impassable. Local communities therefore had to be reasonably self-sufficient and close together, hence the tendency for towns to be no more than 10 miles apart in the Midwest.

The first known concrete pavement in the US was built in 1893 in Bellefontaine, Ohio, and is still in use at present. The 6" concrete was hand placed in two layers and grooved to provide traction for horses. Following this, concrete pavements were constructed using forms and hand placed concrete up until 1949 when the first slipform paver was used for a roadway. Hand placing could achieve about 1,000 to 2,000 ft per day, while slipforming increased productivity by up to five times. By 1955 several manufacturers had begun marketing slipform pavers.
Smooth, firm, paved surfaces meant that vehicles could move further in a given time. This in turn meant that people could live in ever larger cities, because the resources they need do not have to be locally derived.

PRESENT

Over time, slipform technology has changed steadily with current machines able to pave up to 50 feet wide and more than 20 inches thick (for airfield applications). Other innovations in these machines include:

- Stringless control systems, removing the risk of errors incurred by people bumping or tripping over the stringline used to guide the paving machine. Smoothness can be significantly improved, so resulting in improved fuel economy of vehicles using the pavements.
- Electronic control systems, making it simpler for operators to control the machine.
- Steerable tracks, refining set-up and control of the machine.
- Adjustable pans to allow placement of varying crossfall sections.
- Augurs or plows that help control the head of concrete in front of the machine.
- Vibrator monitors to indicate whether vibrators are operating as intended.
- Real-time smoothness sensors, allowing the crew to monitor smoothness on the fly and make rapid adjustments.
- Dowel bar inserters, removing the need for baskets in front of the paver, facilitating delivery of concrete to the front of the machine.
- Wider machines allow construction of multiple lanes and/or shoulders in one pass, shortening construction times.

In terms of the materials and mixtures used in slipform concrete paving, there have been many changes over the last few years. Early on, proportions were based on volumetric ratios which made it difficult to control properties, because changes in the moisture content can change sand volumes by up to 20 %. Adoption of weigh-batching improved batch to batch uniformity.

Like structural mixtures, concretes for paving used to be specified on the basis of slump, strength, and air content. However, these parameters were found to be poor indicators of the concrete durability. There was a period in the 1980s when high strengths were provided, yet the mixtures proved to be non-durable because they were highly permeable. Considerable work has since been conducted to identify what the critical parameters should be, how to measure them, and how specifications can be written to control them. A standard practice published by AASHTO (R101) has recommended that mixtures delivered to the front of the paver should be assessed by monitoring six critical properties: workability, permeability, cold weather resistance, aggregate

stability, strength, and shrinkage. Test methods, such as resistivity and the VKelly, have been developed and standardized that allow rapid measurement of these properties.

Another suggestion in R101 is that many of the properties of a potential mixture should be assessed in the laboratory early on, while acceptance testing should be based on confirming that the mixture delivered is similar to the prequalified mixture. Acceptance testing also needs to evaluate whether factors demonstrating variance within the construction process, such as water and air contents, are within limits.

Early concrete paving mixtures contained four ingredients, rock, sand, cement and water. Mixture proportioning was relatively simple, and rules of thumb based on a strong correlation between cement content and performance were valid. However, current systems add intermediate aggregates, supplementary cementing materials, and chemical admixtures that invalidate the rules of thumb and makes proportioning more complex. Work is ongoing to develop tools to proportion mixtures that can meet a number of additional demands including: reduced cement content to limit carbon footprint, workability appropriate for the equipment in use, sufficient durability for the environment and mechanical properties to carry the loads.

Controlling the combined gradation of the aggregate system using tools like the Tarantula curve has been found to have a positive impact on workability, thus allowing reduction in binder contents while maintaining desired mixture properties. An example is two test sections built at MNRoad in 2022; one using a conventional mixture, and another where gradations of the same materials were adjusted, and the binder content was reduced by 12 % (~70 pcy). Test data from both sections are similar, indicating that just adding cement to a mixture may not solve problems.

There is increasing use of recycled concrete (RCA) as aggregate in the base and in the pavement. This reduces disposal needs and can allow the old pavements to be fully recyclable. Equipment is available that crushes and classifies the recycled concrete on the grade, thus reducing haul costs and fuel consumption. Some quality controls are needed, particularly if the RCA is used in concrete, primarily to control the dust content in the system.

Non-steel dowels are finding application in new pavements. Advantages include zero risk of corrosion and lighter baskets reducing injury risks to the site crew. They have been used successfully at times when local supplies of steel bars have been constrained.

Design practices for pavements have also changed. Tools such as AASHTOW are Pavement ME Design, PavementDesigner.org and Optipave are available to help designers make more efficient use of the materials while delivering longer performing pavements.

Concrete overlays placed over all types of existing pavements have proven to be effective at making use of equity already in the structure, reducing disposal needs, reducing the time to upgrade a system, and providing long lasting surfaces. FHWA's EDC6 program is promoting the use of overlays for pavements. Careful planning and scheduling recently allowed 9 miles of concrete overlay to be placed in Iowa in 25 days from closure to re-opening, while residents only experienced property access issues for a maximum of 3 days.

Other innovative materials are also allowing overlays to be increasingly effective. Fibers are allowing construction of thinner sections, or larger panels, thus keeping saw cuts outside of wheel paths. Non-woven geotextiles installed between layers in unbonded overlays simplify construction and provide effective drainage below the overlay. Internal curing provided by inclusion of small amounts of lightweight fine aggregate is effective in reducing warping as well as reducing permeability in overlays and bridge decks.

Innovative tools for the contractor include maturity testing to provide guidance on when the new pavement can be opened to construction traffic, real time smoothness sensors, ultrasonic pulse velocity sensors for assessing when sawing is needed, and resistivity-based devices that signal when sawing and curing are needed.

The biggest change is that the typical design life is being extended from 20 to 40 years or beyond. While this does not impact embodied carbon at the time of placement – it does have a significant effect of reducing lifecycle environmental impact.

FUTURE

There is a large impetus to reduce carbon footprint, both at the time of construction, and throughout the life of the pavement. It is critical that while cement clinker content in the mixtures can be reduced, long term performance must not be compromised. It is being observed that leaner mixtures are less forgiving of mistakes, meaning that quality systems have to be tighter, and field staff need to be adequately trained.

While strengths may be satisfactory using low-clinker cements, other properties such as setting times, bleed rates, shrinkage and modulus of elasticity may be changing, further requiring that designs and construction practices must be appropriately modified to accommodate these changes. New tools are needed to help field staff make decisions about sawing, finishing, and curing; tools that go beyond the old rules of thumb that may not be valid for future cementitious systems. Work is ongoing at the CPTech Center to develop methods and tools to monitor the quality of concrete as it passes through the construction process.

In the future. effective sensing devices and communications tools will allow paving machines to be more autonomous, but considerable work is still needed to get us there!

This is an exciting time to be involved in the concrete pavement industry with many challenges and rewards as we work to deliver the backbone of civilization. **CB**

This article was first published in Roads & Bridges, January 2024. Reprinted with kind permission.

DR. PETER C. TAYLOR P.E. (IL)

Peter Taylor is the Director of the National Concrete Pavement Technology Center at Iowa State University.

He holds a PhD in Civil Engineering from the University of Cape Town, and is a Professional Engineer, registered in Illinois and active in a number of professional societies.

The use and condition of Reinforced Aerated Autoclaved Concrete planks

Prepared by Edwin A.R. Trout, Executive Officer, ICT
Reviewed with minor revisions by Prof. Chris Goodier, Loughborough University, UK.

BACKGROUND

The use of reinforced aerated autoclaved concrete (RAAC) in the form of lightweight planks for roofing is a long-established, if now largely superseded practice in the UK. But it has also been known since the 1990s to be subject to limited durability and the prospect of sudden failure, and is increasingly seen to represent a threat to safety. Whereas investigations into safety, by the Building Research Establishment in the 1990s, focused on the use of RAAC designed and manufactured before 1980, latterly it has been found to have been used in public sector buildings erected during the 1990s, significantly later than previously thought. Buildings investigated by the Standing Committee for Structural Safety (SCOSS, now CROSS) date from 1991-98, and the latest subject of a CROSS safety report, issued in 2022 after investigations in 2018-19, refers to a roof built in 1991. This is a pitched roof of RAAC planks, covered in a membrane, felt and concrete tiles, and sited in a hospital – alarmingly over an operating theatre. The presence of RAAC discovered in this and other hospitals over the past five years has prompted a countrywide review of the National Health Service (NHS) and Department for Education (DfE) estate and a major programme of remediation and investment. Putting the problem into perspective, long-term researcher Professor Chris Goodier (Loughborough University) explains: "There's nothing wrong with RAAC per se, but you need to use it in the right place and look after it": a small proportion is not manufactured well, not installed correctly, or not maintained properly [Weinfass].

AERATED AUTOCLAVED CONCRETE: THE MATERIAL

Aerated autoclaved concrete is, more accurately, a mortar of cement paste, often combining fly ash or ggbs. It contains no coarse aggregate, but rather air voids created from the bubbles generated by a chemical reaction during steam curing. Aluminium powder added to the mixture reacts with lime to produce hydrogen gas, bubbles of which then permeate throughout the concrete. The resulting closed-cell structure allows easy identification when exposed.

The desired property of aerated concrete is its reduced weight and this material is generally 400-600 kN/m^2 compared with normal-weight concrete that is closer to 2400 kN/m^2. It is, however, also of low strength (10-20 % the compressive strength of 'normal' concrete – typically 3 to 5 N/mm^2) and sufficiently soft to cut to size and accommodate fixings inserted with hand tools. Significantly for structural applications, it has a reduced capacity for bonding to reinforcement, and so welded transverse bars for anchorage are required.

AAC is inherently a factory-made product, and is manufactured in the form either of blocks – well known from their use as the inner leaf of cavity walls – or larger, reinforced structural units such as wall or façade panels, and roofing planks or even floor slabs.

RAAC: IN THE FORM OF PLANKS

RAAC planks were made in a range of widths and depths, typically 600 mm wide (though ranging from 300-750 mm) and 100-250 deep (with 75 mm as a minimum). Spans cited in the literature range from 2.4 m to 6 m, with elements usually supported by steel beams, though sometimes by masonry walls or concrete ring beams. Some have a rebated top edge detail or chamfer, forming a groove joint between adjacent planks.

Typically, RAAC planks were reinforced with longitudinal reinforcement placed top and bottom. Transverse bars were welded to this reinforcement at intervals to provide anchorage. Given the insufficiency of alkaline protection offered by AAC, reinforcement was usually coated with either a bituminous (to the 1970s) or cementitious latex coating to resist corrosion.

Edwin A.R. Trout

USE OVER TIME

Developed in Sweden in the 1930s, RAAC was introduced to the UK in the late 1950s, its use promoted by an influential article in the Structural Engineer of January 1961: 'The structural use of aerated concrete' by A. Short and W. Kinninburgh. It was used extensively, typically in schools and hospitals and throughout the public sector, particularly between 1963 and 1978. The generic product was marketed in the UK under two trade names: 'Siporex', produced and sold in the north, and 'Durox' in the south.

RAAC was not used to any great extent after the early 1980s – British manufacture ceased in 1982 – though, as indicated in the introduction, it is still found in buildings of the mid to late 1990s. Indeed, it remains an option in principle even today, its use guided by successive standards: BS 8110 (1985-2001) and EN 12602 (2008-date), with CE marking required after 2013. The design and manufacture of any planks produced under these standards will of course have been different from that of the earlier pre-1980

practice, (though CROSS admits to having no information on how these more recent changes will have affected RAAC construction in practice).

INVESTIGATION OF FAILURES IN THE 1990S

The 1990s saw several instances of the failure – generally excessive deflection rather than collapse – of RAAC roof planks that had been installed during the 1960s and several affected buildings were demolished. The material in question had been designed before 1980. These cases were investigated by the BRE:

1991: The BRE tested roof planks removed from a housing development. These exhibited excessive and progressive deflections and widespread hairline cracking of the soffits. The findings are set out in detail in IP 10/96 (p.6).

1994: Dept for Education asked the BRE to inspect the flat roofs of two schools in Essex. After 20 years in service, these were suffering from water ponding on the upper surface and cracking of the soffits. The investigation found deflections of 1/100. Detailed findings were also enumerated in IP 10/96 (p.7).

2002: BRE then issued IP 7/02, entitled Reinforced autoclaved aerated concrete panels: test results, assessment and design, but with no comment on durability.

2018 TO DATE: THE EMERGING SITUATION

In 2017 a school roof failed in Bolton, then in 2018, a report received via the Local Government Association about the collapse of a plank from a flat roof at Singlewell primary school in Gravesend, Essex – fortunately above an empty staff room – resulted in a SCOSS Alert: Failure of reinforced aerated autoclaved concrete (RAAC) planks (May 2019). It was the first indication of the current alarm.

In the first instance, attention was focused on the health sector. By November 2019, checks were being carried out at seven affected hospitals, though many trusts had been surveying and remediating their RAAC buildings prior to this. The 2020 Spending Review set aside substantial funding to help the NHS address this problem, NHS England's director of estates declaring that RAAC planks posed a "significant safety risk". By 2022, 20 hospitals in 18 different NHS trusts had been identified as having RAAC-related problems, with several now subject to emergency support and monitoring. Indeed, the Minister of State for Heath disclosed in August 2022 that 34 NHS buildings contain RAAC.

Requests since made by NCE magazine under the Freedom of Information Act have revealed that five of the worst affected trusts have applied for a combined £331.9m of additional funding to fix RAAC problems over the next three years: 2022-23 to 2024-25.

- Queen Elizabeth Hospital King's Lynn NHS Foundation Trust
- North West Anglia NHS Foundation Trust (Hinchingbrook and Stamford & Rutland)
- West Suffolk NHS Trust
- Mid Cheshire Hospitals NHS Foundation Trust (Leighton Hospital, Crewe)
- Frimley Health NHS Foundation Trust

At the Queen Elizabeth Hospital in King's Lynn, for instance, 4,394 steel props are holding up a roof across 56 different areas of the building and a team of 12 monitoring safety 24 hours a day. The Trust applied for £90M to be spent between 2022-25 on installing structural failsafes across the entire first floor of the hospital.

In March 2023, it was announced that the outpatients building at Stoke-on-Trent's Haywood Community Hospital is to be replaced by a new building costing £25.5m, as part of a national scheme to remove RAAC from all NHS buildings. In May 2023, it was announced that five hospitals are to be rebuilt by 2030 as a priority under the New Hospital Programme, largely coinciding with those listed above:

- Queen Elizabeth Kings Lynn, Norfolk
- Hinchingbrooke, Cambridgeshire
- Airedale, West Yorkshire
- Leighton, Cheshire
- Frimley Park, Surrey

However, RAAC is not expected to be fully eradicated from the NHS estate until 2035. But in addition to the review of hospitals, the Local Government Association and Department for Education have contacted all school building owners to offer advice, warning that many such buildings were close to collapsing. A DoE report in July 2021 had raised the risk level to "~critical, very likely" and a NAO report of June 2023 identified 572 schools built in the years 1930-1990 and thought to contain RAAC, 24 requiring immediate attention. In May 2023, the Ministry of Defence confirmed it was urgently investigation hundreds of its buildings. Then in June 2023, the Office of Government Property announced it was convening a working group in which a designated representative from each government department would be present. In so doing, surveys into the effects of RAAC have now been extended to the Government's entire £158bn estate, with warnings that many formerly public-sector buildings will now be in private ownership and probably not surveyed.

2023: THE DEPARTMENT FOR EDUCATION AND THE CLOSURE OF SCHOOLS

The most recent media coverage, bringing the issue of RAAC to a national audience, stemmed from a decision by the Department for Education at the end of August to close the affected premises of any school identified as having RAAC, regardless of their previous risk rating. The number of schools in England thought to have RAAC was said to be 156, of which 52 had mitigatory measures in place, but 104 faced the immediate closure of some or all of the buildings on their premises just days before the start of term.

The DfE explained that "recent cases have led to a loss of confidence in buildings containing the material, leading us to advise education settings (schools, colleges and maintained nursery schools) to vacate all spaces or buildings that are known to contain RAAC, unless they already have mitigations in place to make the building safe." The new guidance was said to have been "sparked by the collapse over the summer of a beam at a school that had been considered safe" [Daily Mail, 2 Sept] and the education secretary subsequently revealed that the sudden failure over the summer of three RAAC planks previously classified as non-critical prompted the decision. In a statement to Parliament, Gillian Keegan said surveyors discovered the non-critical RAAC failures during a programme of assessments that started in September 2022. The three failures that happened without warning were in buildings where the risk was previously classified as non-critical. The first was in a commercial building, the second in a school, with the most recent failure, which came to light at the end of August, prompting the decision to close the additional 104 school buildings [Construction Enquirer, 5 Sept].

It was also explained that a CROSS report, filed just a week before the Government's decision shut school buildings, revealed that that some of the surveys were based on faulty calculations – assuming that RAAC has the similar properties as structural concrete – and that the conclusions must therefore be deemed unreliable. The timing of its publication would

appear to help explain the sudden alarm at the DfE that led to the school closures [Construction Index, 26 Sept].

By 7 September, the Government had published an official list of 147 schools in England it says were built using reinforced autoclaved aerated concrete. A further nine schools initially thought to include buildings made with RAAC were found to have none, though the final tally was expected to grow as more assessments were received [BBC News, 7 Sept]. By October the number had risen to 174 and by 27 November, 231 [BBC 7 Dec. The DfE confirmed that school building projects already committed to would not be rescheduled from the existing programme due to the RAAC crisis. 400 school projects already identified were to remain in the Government's 10-year programme of building 500 schools, through the remaining 100 places still to be allocated in tranche 5 would probably be reserved for RAAC rebuilds [Construction Enquirer, 12 Sept].

The publicity given to the school situation led to a series of closures in other sectors. Theatres in Dartford, Northampton and Carlisle were closed within days of the DfE announcement [Construction Index, 6 Sept]. The perception was that the problem was widespread: police stations, leisure centres, barracks and MOD training facilities, six buildings in the court system.

MECHANISMS AND THE RISK OF FAILURE

Failure can be gradual or sudden, but if sudden there is no warning and as RAAC is often used as a roofing material, the consequences of failure can be serious. The 2019 SCOSS Alert showed that the failure in question was "due to a brittle shear failure at or close to the bearing", which is still the most critical and worry type of failure. (Consequently, inadequate bearing size and/or inadequate steel reinforcement over the bearing remain the most critical high-risk factors.) However, there are several likely mechanisms of failure: the high volume of entrapped air makes it susceptible to moisture ingress and carbonation, and so RAAC is less robust that structural concrete, ageing much less well. The BRE in 1996 identified "excessive deflection and cracking" and "spalling" as matters of concern, and found some evidence of the "initiation of reinforcement corrosion". In summary, contributory factors that can lead to failure include:

- Spalling and cracking – representing a particular risk if the cracking is close to a support
- Water damage – strength is reduced when the material is wet, and the planks will weigh more
- Adverse loading and displacement of planks – offering the risk of ponding
- Ineffective repairs – risk arising from the poor bonding of incompatible materials [Atkins & Rolf]

Instances of failure have hitherto been few, but as the buildings that typically incorporated RAAC elements reach their oft-quoted (though unsubstantiated and disputed) 30-year service life, the rate of failure is increasing and is evidently being taken seriously in the public sector.

Action to be taken by those responsible for buildings containing RAAC

1. Check records relating to construction for indications that RAAC was used.
2. If its presence is suspected, an inspection should be undertaken.
3. In the event of deflections (1/100 of the span), significant cracking or small bearing widths (less than 40 mm), commission a structural assessment.
4. Where deterioration is found, prepare a risk assessment, decide on a maintenance regime, take out insurance and plan emergency responses.

Methods of testing and appraisal for risk of corrosion in RAAC has been developed by Concrete Prevention Technologies in partnership with on-going work by the Loughborough University RAAC Research Group, and in November, it was reported that the Government had awarded a £3m grant to the Manufacturing Technology Centre to develop new, non-destructive technologies to identify RAAC and assess its condition, and to automate the collection and analysis of data. [Construction Index, 28 Nov]

GUIDANCE

BRE: Reinforced autoclaved aerated concrete planks design before 1980 (IP 10/96) – contains a preliminary inspection procedure and advice on maintenance

CROSS Theme Page: Structural safety of reinforced aerated autoclaved concrete (RAAC) planks – collates all information published by CROSS

IStructE: Reinforced aerated autoclaved concrete (RAAC) panels: investigation and assessment – further guidance by the IStructE Study Group

In the wake of the schools' crisis, the Construction Leadership Council has set up a technical panel from industry experts and representatives of the appropriate professional bodies, along with a communications and external engagement group to ensure the flow of accurate information and guidance. **CB**

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LET'S REWRITE BAG BY BAG THE STORY

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How supplementary materials are transforming cement's potential

By Mike McDonald, Manager of the Centre of Product Excellence (CPE), AfriSam, South Africa and
Dr. Grizelda du Toit, Project Professional at AfriSam, South Africa

With the manufacturing of Portland cement being responsible for an estimated 8 % of global greenhouse gas emissions, there is still considerable potential for cementitious alternatives like fly ash (FA) and ground granulated blastfurnace slag (GGBS) to help reduce the industry's carbon impact.

Cement remains a cornerstone ingredient for economic and social development around the world, but there is growing concern about its carbon impact – an impact that is driven mostly by the energy-intensive clinker manufacturing process. The sustainability profile of the sector can be enhanced if cement manufacturers can decrease the clinker proportion by employing alternative materials with reduced carbon footprints.

For the stakeholders in the sector, a vital concern is that the performance of cement is not compromised in any way by these efforts. It is therefore heartening to reflect on the progress already made in this endeavour by companies like AfriSam in South Africa – and the opportunities that this creates for the local and international industry.

Dr Grizelda du Toit, AfriSam Project Professional.

Mike McDonald, AfriSam Centre of Product Excellence Manager.

AVAILABILITY OF MATERIAL

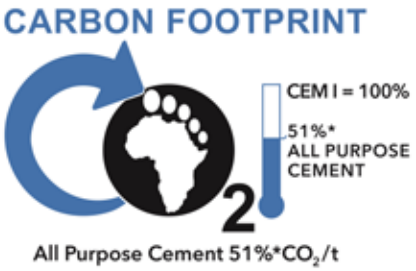
To contextualise, it is important to point out that South Africa has been reliant on electricity from coal-fired power stations for many decades, and remains so. One of the results is that the northern region of the country has access to substantial volumes of fly ash, which is deposited in large dumps adjacent to the power stations. It has essentially been regarded as a waste product, although its increasing re-use has changed this status to 'by-product' – with potential implications for its cost and management. South Africa also has some resources of GGBS slag from the steel-making process, although these are also limited to certain geographic locations.

Cement producers in the country have therefore had many decades in which to explore the application of these cementitious alternatives. AfriSam, for instance, introduced a 'green cement' range as early as 2000, and was the first cement company in Africa to launch CO2 labelling on its cement bags in 2009. AfriSam's cements make a valuable contribution to customers' efforts to reduce the carbon footprints of their construction projects.

In fact, the science of reducing the carbon footprint of cement is now well advanced – and there are opportunities for users to safely extend their ambitions when designing green projects that have a cement component.

QUANTIFYING CARBON

Firstly, however, it is useful to quantify the carbon contributions of cement manufacturing to understand where the environmental gains are most fruitfully pursued. About 60 % of the carbon footprint of cement is associated with the decarbonation of the main raw material, limestone, while about 40 % relates to the electricity, diesel fuel and other manufacturing activities.



AfriSam was the first company in South Africa to publish the CO2 footprint of each product on the cement bag.

The carbon footprint for both FA and GGBS is much lower than that of cement, due to the protocol where the main material carries the carbon penalty and by-products are exempt. Research shows that FA has the potential to replace 20 to 50 % of Portland clinker, while GGBS has the potential to replace 50 to 90 %. Overall, this presents an opportunity to reduce the clinker factor in cement by 30 to 50 %.

The benefits of this scale of clinker reduction are numerous. In line with most climate change policies on a national and

corporate level, there is a reduction in the carbon footprint of cement – and hence of the concrete in which it is a component. Where the supplementary cementitious material can be sourced cost-effectively – as it can especially in the case of South Africa's FA – the cost of producing building products can also be reduced. In general, the 'recycling' of FA and GGBS also aligns well with the forward-looking philosophy of the circular economy.

ENHANCING DURABILITY

Perhaps the most exciting aspect of these technological advances, however, is the positive effect that these supplementary cementitious materials (SCMs) can have on selected durability and physical properties of concrete. Classified FA, for instance, is considerably finer than Portland cement, and its inclusion in cement assists concrete to pack more densely – making it less permeable to aggressive external elements. Apart from its compressive strength, a key function of concrete is to protect the reinforcing steel within it; the fine residue of FA can help to make the concrete more difficult to permeate, and reduce the risk of the steel oxidising, expanding and cracking the concrete. The oxygen permeability test – designed in South Africa by leading expert and academic Professor Mark Alexander – has shown that concrete with FA is demonstrably less permeable.

The spherical shape of the ash particle also creates the 'ball-bearing' effect, making concrete more workable, with a decreased water demand and even facilitating a quality off-shutter finish.

Other important tests for concrete durability include chloride conductivity and water sorptivity. In both these cases, the addition of SCMs can contribute in a positive manner. GGBS is known for its ability to 'capture chloride', and so is highly effective in areas where high levels of chloride are present, such as coastal areas. As a small molecule, chloride is able to easily penetrate concrete which is not properly prepared, and can create an iron-chloride that rusts the reinforcing bar. When GGBS is used, it effectively binds the chloride and prevents it from proceeding further into the substrate beyond the first few millimetres.

FURTHER PROCESSING

An advantage of FA is that it does not require additional energy intensive processing, like milling, before it can be used successfully in cement and concrete, although it has been proven that significant additional reactivity can be achieved by means of mechanical activation. In the case of GGBS, the raw slag is quenched with water to produce granulated grains, which results in a material consisting of predominantly amorphous phase (glassy phase) and has the physical size of a sand kernel. This material is then dried in a coal-fired flash drier before being ground in either a ball mill or a vertical mill to a fineness approaching that of baby powder. However, this is an energy intensive process which adds to the carbon footprint of the final material. Both of these SCMs are then ready to be added in a cement blending system, to manufacture Portland cement products in compliance with the EN 197 (in South Africa, SANS 50197) specification.

ADMIXTURES

It is worth remembering that the reaction mechanism of these SCMs are dependent on the production of calcium hydroxide (CaOH) produced during the hydration process of the Portland clinker. This can be enhanced by the addition of selected admixtures, that can either work to accelerate the cement hydration process, or act directly on enhancing and accelerating the solubility of the mineral components. The correct

AfriSam introduced a 'green cement' range as early as 2000.

GGBS has the potential to replace 50 to 90% of Portland clinker.

FA makes concrete less permeable to aggressive external elements, protecting the reinforcing steel within it.

FA makes concrete less permeable to aggressive external elements, protecting the reinforcing steel within it.

use of suitable admixtures will lead to an optimal content of SCMs in cement and concrete, thereby significantly increasing the sustainability effects.

RESEARCH RESULTS

There exists scope for the consideration of alternative and/or additional activation methods, like the further grinding (mechanical activation) of FA in a cost effective manner, which will result in an enhanced SCM with improved reactivity within in the final cement product. AfriSam research proved that, with a combination of well thought out and optimally designed activation methods, cement containing 70 % FA is able to comply with the strength requirements of a 32,5R cement.

However, the EN 197 (SANS 50197) standard permits only up to 55 % ash content, and compliance to this specification is compulsory for cement producers. In this sense, the standard effectively limits the use of South Africa-specific materials such as FA. There is certainly the need to maintain stringent standards for cement manufacturing; what is worth considering is a more frequent assessment the standard, in light of industry-based research and development, and more specifically towards the availability of alternative materials pertaining to a specific country.

There is no specified limit on the FA level in concrete, but the specifying engineer must feel professionally assured that the required results will be achieved, and the mix design must be optimised to meet the specification. There is still a high level of risk aversion in this regard, where concrete mixes are specified along with a maximum portion of FA – typically about 30 %.

It is also worth noting that concrete strength requirements are normally specified to be met after 28 days, despite our own tests and experience, and an abundance of published research, showing that concrete containing these SCMs continue to gain significant additional strength beyond the 28 day mark – from 15 % to 25 % – up to 90 days. The 28-day convention is based on the behaviour of Portland cement, where the extent of the hydration reaction is mostly completed within this period. The latter is not the case when SCMs are included in the concrete. In fact, tests suggest that strength gain continues beyond six months and up to 12 months, however at a decreased rate.

CLIMATE CHANGE

With the growing commitment within all sectors of industry around the world to minimise greenhouse gas emissions, it is becoming imperative that engineers and contractors embrace materials that embody lower carbon footprints. Cement producers like AfriSam are spending a great deal of time and resources in product development to continuously reduce the carbon levels associated with our offerings – while ensuring that they perform like conventional cement, or better. We have established that through the right scientific mix designs, these green cements can perform in line with expectations in terms of workability, strength, shrinkage, durability and other performance parameters.

In order for real progress to be realised toward a lower carbon future, the onus will be on cement users to commit to, and explore these modern options with their supply partners. By putting mixes with SCMs to the test, in a considered and closely monitored fashion, it is likely that the benefits will be quickly realised. **CB**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Creating Concrete Possibilities
AfriSam

A concrete attempt at taming the "wildest", "wickedest" river

By David Poggiolini

Spanning more than 2,3 km across the Yangtze River; 2 309 m wide; and towering 181 m in height, the Three Gorges Dam retains almost 40 billion m^3 of water in its 1 million km^2 catchment area.

The plant was built by the Chinese Central Government to finally tame the "Long River", described by American writer and novelist, Pearl Buck, as the "wildest, wickedest river on earth". This is due to the extensive destruction and loss of life that it wreaked on river basin communities when it burst its banks.

A further motivation for building the infrastructure was to generate large amounts of clean and cost-effective electricity and achieving water security for China's growth.

When the Three Gorges Dam started operating in 2012, it was officially the world's largest hydroelectric plant, generating 22 500 MW of electricity.

However, this is not the only record that this mega-infrastructure project, which the Chinese Central Government says cost US$37,23 billion, has broken.

The Three Gorges Dam can also stake its claim to being the largest concrete dam in the world. A total of 14,86 million m^3 of concrete was placed to construct the dam cross-section, alone.

This is in addition to the enormous quantities of concrete used to construct the other components of the hydropower station. Over the 18-year-long construction period, China Three Gorges Corporation (CTGC) placed just under 30 million m^3 of concrete, reinforced with 354 000 t of steel.

In 2000, the Central Chinese Government also broke records for the largest yearly, monthly and daily concrete pours ever undertaken – a staggering 5,48 million m^3, 553 500 m^3 and 22 000 m^3, respectively. This was also a proud moment for the 25 000 individuals who worked on the project when it peaked.

Due to the complexity associated with handling and placing such large quantities of concrete, various processes were first simulated and the preferred method then refined and put into practice.

Seven computer-controlled concrete batching and mixing plants were deployed. The two located downstream on the right bank each had a capacity of about 350 m^3/h. This was bolstered by the between 240 m^3/hour and 400 m^3/hour production capacities of the two and three batch plants located upstream and downstream of the left bank, respectively. Concrete for the construction of the navigation locks were supplied by two adjacent concrete plants located on the downstream right-side of the locks.

All of the specified aggregate and sand excavated from the foundation pits were used for concrete production and supplemented with sand manufactured by a vertical-shaft impactor.

Most of the concrete was placed using six tower belts, each providing a peak productivity rate of between 100 m^3/h and 200 m^3/h. Additional capacity came from haul trucks that transported concrete to feeder conveyors or crane lay-down buckets wherever necessary.

As the dam gradually reached its final height, the conveyor belts were lifted with six tower cranes equipped with jacks. Concrete was also placed with the crane's swinging telescopic conveyors that had a 450 m^3/h design capacity. A mobile crane delivered concrete from a large haul truck to construct the dam's left wall.

Maintaining optimal curing conditions was critical. This is considering the substantial heat that concrete placed in large quantities generates when it sets, compromising its strength.

The system implemented to maintain concrete at about 7°C was the largest and most sophisticated at the time.

Firstly, the aggregate regulation bin in the secondary screening circuit was used to air-cool the coarse aggregate. Secondary aggregate cooling then took place in the mixing plant's material bin. This clever process included ground-air cooling and a highly efficient fan and distribution system that created a cool-air circulation system inside the bin.

The batching plants also featured cold-air, water and sheet ice-cooling capabilities. Moreover, post-placement cooling pipes through which chilled water was pumped were used in areas where concrete was placed en masse. These interventions also helped to maintain concrete temperatures during the warm summer periods.

A high-performance 60 MPa concrete mix was designed to construct about 231 000 m^2 of water-tight concrete walls.

An artificial aggregate consisting of non-alkali active granite was selected as the most suitable material to meet the concrete's high-performance requirements. Alkali content was strictly controlled to less than 0,5 % in the cement clinker and below 2,5 kg/m^3 in the cement and Class I fly ash. Containing a high proportion of fine particles, the fly ash improved the workability of the concrete and slowed the alkali-active reaction to provide savings in slurry consumption. In turn, this helped to prevent temperature-related cracking and dry shrinkage. A high-quality and -efficiency water-reducing agent was also incorporated into the mix to further reduce water consumption savings already achieve by fly ash from 110 kg/m^3 to 85 kg/m^3. Increasing the amount of fly ash by reducing the water-to-gel-ratio also improved the durability traits of the concrete.

To better manage the swift placement of large volumes of concrete, a comprehensive set of quality assurance and construction systems were developed specifically for this project.

Real-time monitoring; dynamic adjustment; and optimal regulation of the entire construction process was supported by an integrated computer-monitoring and -control system.

However, many have questioned whether the extensive time, money and effort allocated to this project were worth it. These doubts again came to the fore in 2020 when the dam failed to tame the river during the heaviest average rainfall in nearly 60 years. 158 people died or went missing; more than 3 million residents were displaced; and over 54 million citizens were affected by the catastrophe in some way.

Certainly, the dam has also had significant dire environmental and social consequences that cannot be ignored.

Moreover, in 2002, cracks were identified in the dam wall. The fissures were promptly repaired but have since reopened.

However, Chinese authorities continue to stand by their project. They note that it played a crucial role in mitigating a severe disaster during the recent floods. Then there are the other host of benefits that it has provided over the years. This includes power generation; navigation; aquaculture; tourism; ecological protection; transfer of water to where it is needed the most; irrigation; and water security. involves working with a team of heritage experts and students from the University of Sydney to analyse the building's concrete, test non-invasive conservation techniques, and develop a management system to monitor the condition and performance of this great building now and into the future. **CB**

David Poggiolini

CCSA Concrete Carbon Model

CCSA model provides a reliable method of determining concrete CO_2 footprint

Cement & Concrete South Africa's (CCSA) concrete CO_2 model is facilitating the design of concrete mixes with a smaller carbon footprint.

Used by, among others, cement manufacturers, ready-mix producers, consulting engineers and architects, CCSA's CO_2 model calculates the carbon-dioxide equivalent (CO2e) associated with the production of a cubic meter (m^3) of concrete.

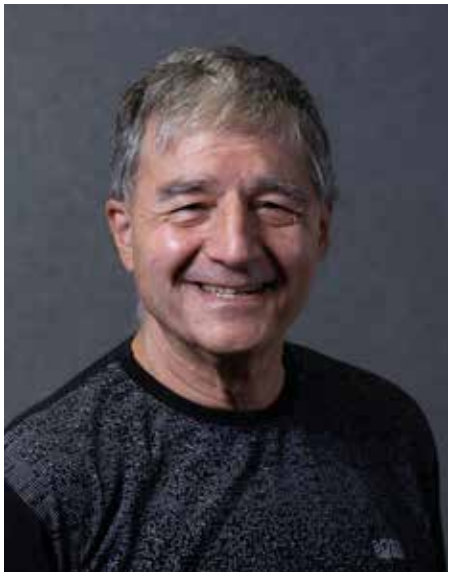
This is determined according to a user-defined concrete mix design. Users of the model select the type of cement deployed in their mix and the end application for concrete. These include, inter-alia, roof tiles, bricks, precast-concrete elements or cast-in-place construction methods.

"Our concrete CO_2 model provides a reliable means of calculating the embodied energy of concrete. This has become a top priority for responsible built-environment professionals who are committed to reducing greenhouse-gas (GHG) emissions of this widely used construction material. Using our model, they are making more informed decisions regarding concrete for their projects," Gary Theodosiou, a Technical Consultant to CCSA, says.

Certainly, CCSA's concrete CO_2 model also raises awareness of "green" concrete, as well as facilitates and recognises environmental leadership in the design and application of the construction material. This is in line with CCSA's focus on the sustainable use of concrete. Just as importantly, it also provides client bodies and their professional teams with a method of accurately comparing concrete's embodied energy with that of competing construction materials.

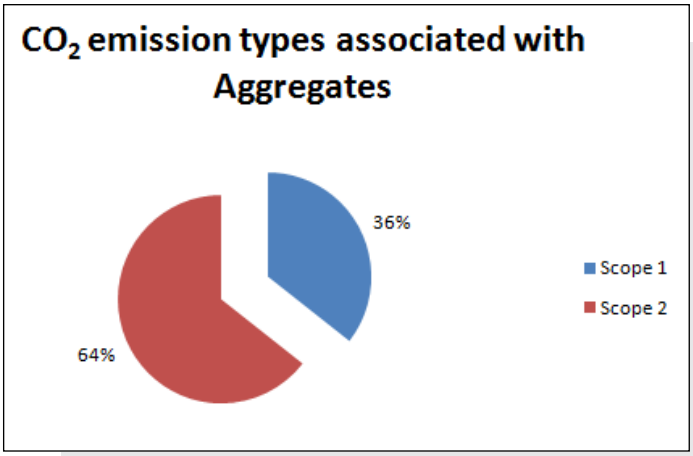
In developing a reliable CO_2 emissions inventory, all components of concrete were considered. These include actions, namely transportation and mixing. This is in addition to the various concrete components, including admixtures; aggregates; CEM I cement; fly ash and ground-granulated blast-furnace slag (GGBS) – both often referred to as extenders – water; and steel reinforcing.

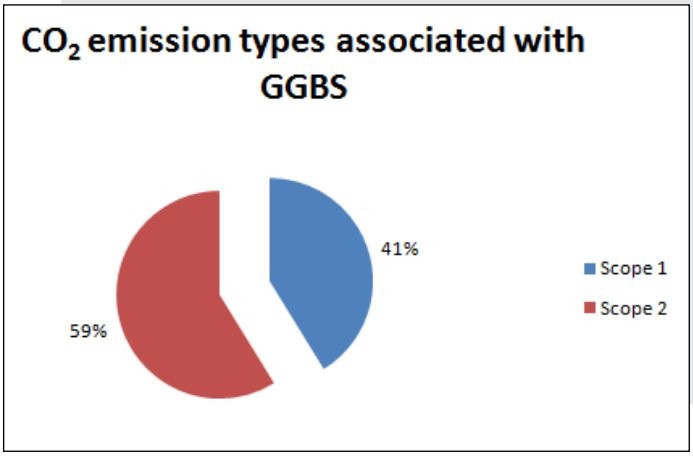
A primary focus for CCSA was to quantify the energy consumption involved in each activity and component. This is considering the large contribution that this function, alone, makes to the carbon footprint of the various actions and components linked to concrete production. The only exception is the cement industry where as much as 50 % of emissions are generated from the calcination/decomposition of limestone in kilns. Electricity and fuel consumption make up the balance of the cement industry's carbon footprint.



Gary Theodosiou

Cement Specific Emissions - 2007									
Cement Type	Composition				Total	Scope 1	Scope 2	Scope 3	Units
	OPC	Fly Ash	GGBS	Limestone					
CEM I	100%	0%	0%	0%	985.4	818.3	145.3	21.8	kg CO_2/ ton
CEM II A-L	85%	0%	0%	15%	838.8	696.0	124.2	18.5	
CEM II A-S	80%	0%	20%	0%	814.0	665.2	131.3	17.5	
CEM II A-V	80%	20%	0%	0%	788.6	654.6	116.5	17.5	
CEM II B-L	73%	0%	0%	27%	721.5	598.1	107.4	15.9	
CEM II B-S	70%	0%	30%	0%	728.3	588.7	124.4	15.3	
CEM II B-V	70%	30%	0%	0%	690.2	572.8	102.2	15.3	
CEM III A	50%	0%	50%	0%	557.0	435.6	110.4	10.9	
CEM IV A	65%	35%	0%	0%	641.0	531.9	95.0	14.2	
CEM IV B	58%	42%	0%	0%	572.2	474.6	84.9	12.7	
CEM V A	57%	18%	25%	0%	594.1	479.7	102.0	12.4	
CEM V B	38%	31%	31%	0%	414.8	327.4	79.1	8.3	





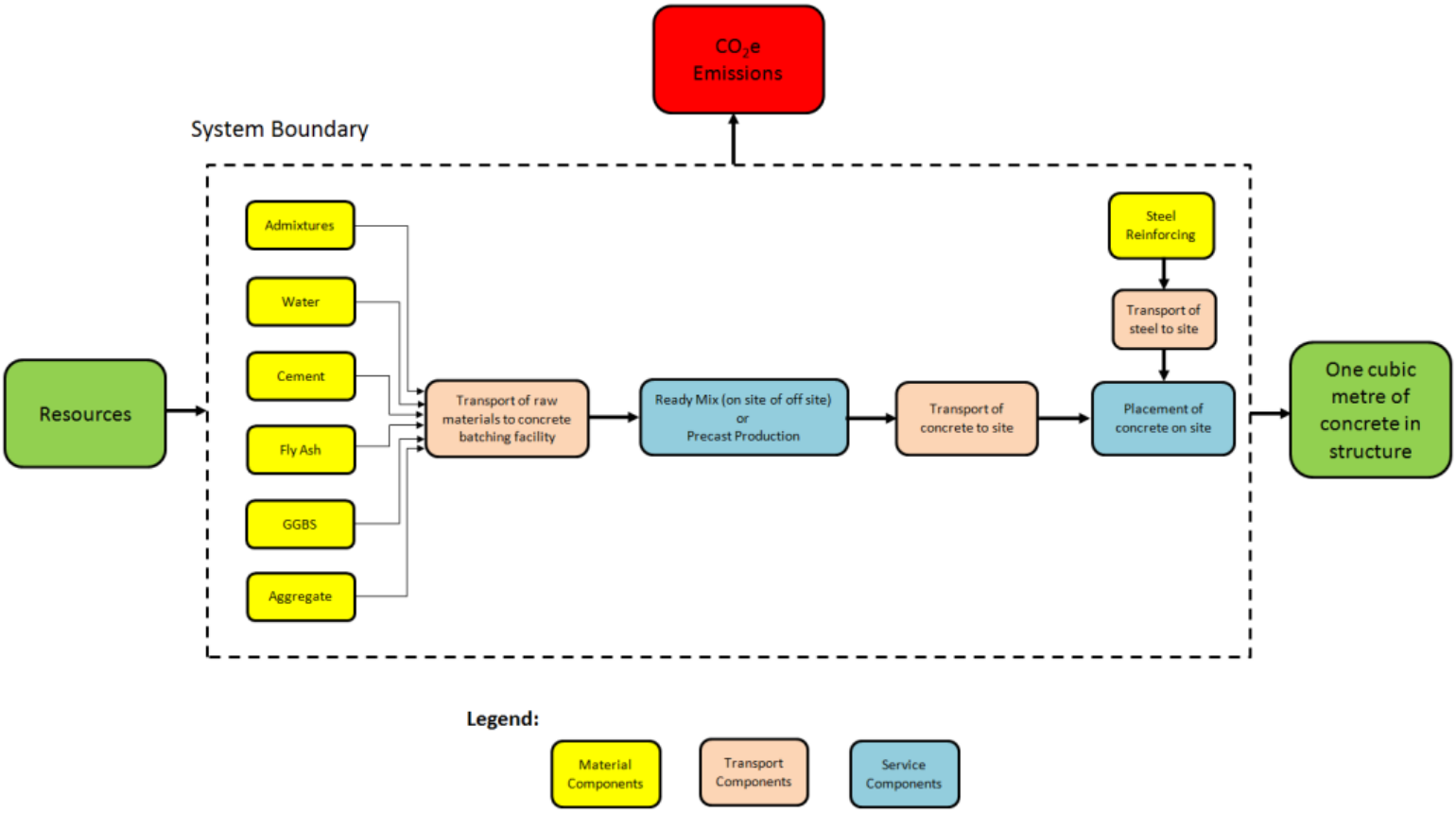
CCSA defines these emissions according to the internationally recognised GHG Protocol. It is also used by the World Business Council for Sustainable Development's approved cement emission model, which was developed further and refined to make it more relevant to concrete by CCSA.

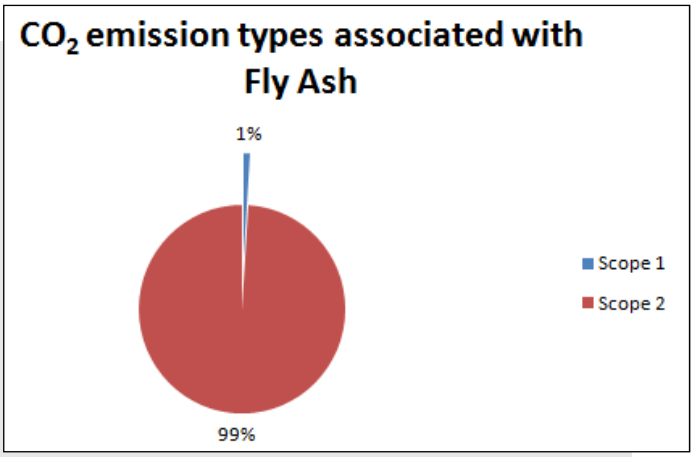
The embodied carbon of eight concrete mixes with a 30 MPa strength were compared. All of these mixes incorporated a CEM I base cement and were designed with and without admixtures for comparative purposes. Moreover, to evaluate the effects of fly ash, GGBS, admixtures, aggregates and water demand on CO_2 emissions, raw material amounts were varied in each concrete mix design.

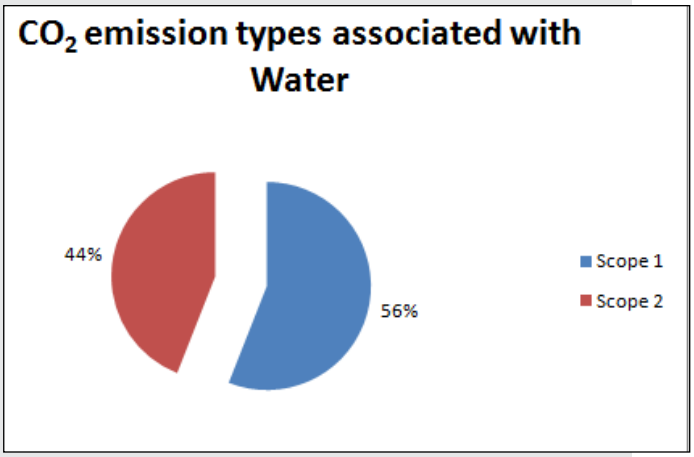
Theodosiou says that CSSA's concrete CO_2 model demonstrates that the carbon footprint of concrete can be reduced in three ways. This is by using a cement extended with fly ash or GGBS; an admixture; or a good quality aggregate and sand with a low water demand.

When plasticizer admixtures are introduced to a CEM I mix design, water demand is reduced by 10 %, resulting in a 17,6 % decline in cement requirement. Overall, the use of admixtures lowers CO_2 emissions by 16 %.

Fly ash can reduce associated emissions by 23 %. When used with an admixture, concrete emissions can be reduced by a further 15 %, resulting in a 38 % decrease in the embodied energy of concrete.





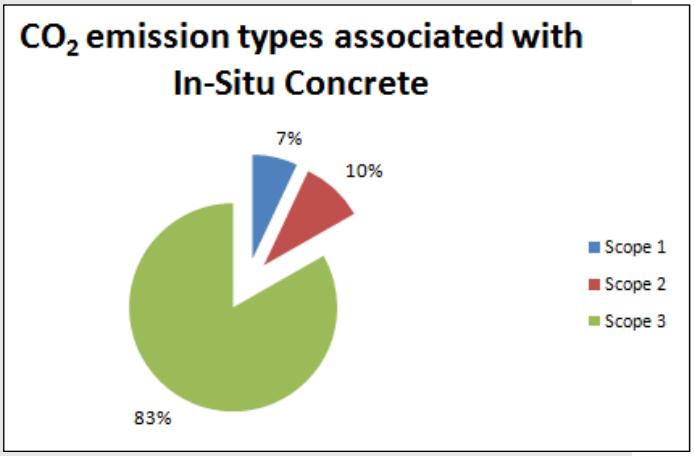


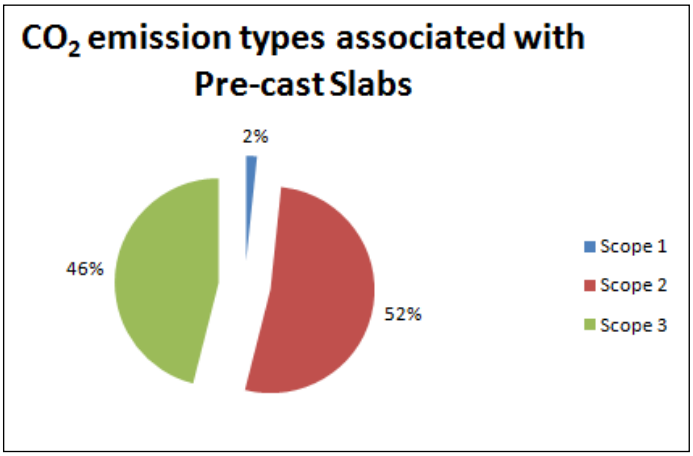
The inclusion of GGBS in the concrete mix can lower CO_2 emissions by between 36 % and 45 % when used with an admixture. This is achieved by replacing up to 50 % of cement in the concrete mix with GGBS.

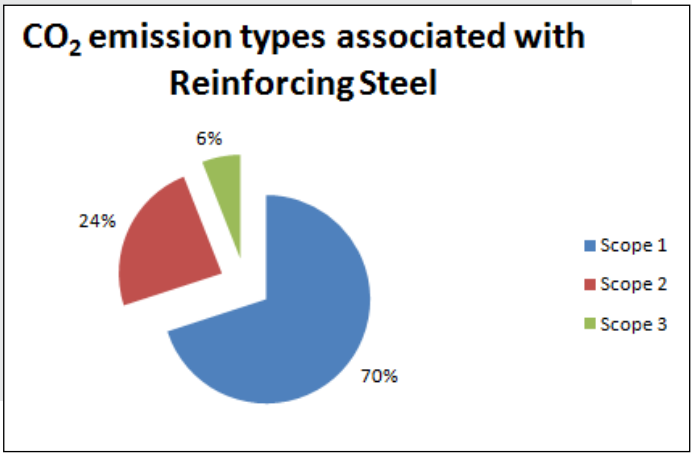
CCSA also tested a concrete mix with decomposed granite sand as an aggregate input. This was to demonstrate the extent of the influence that the type of aggregate used has on the carbon footprint of concrete. A decomposed granite sand mix has a high-water requirement (240 l/m^3) of 76 % or more. Therefore, this leads to an increased cement requirement of 53 %, in turn, raising the concrete carbon footprint by 36 %.

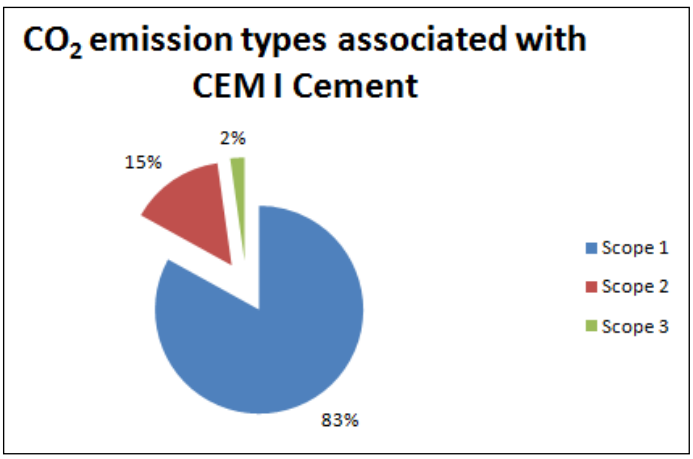
"Considering its many benefits, concrete remains the preferred material for a myriad of construction projects. Therefore, it is also the most consumed material after water, with the average consumption of concrete about one ton per year for every person on earth. Bearing in mind the sheer size of the South African concrete construction industry, alone, the prudent use of this building material can have a significant positive impact on global carbon emissions," Theodosiou concludes.

This model can be accessed on the CCSA website https://cemcon-sa.org.za/information-hub/concrete-tools/concrete-model/ **CB**









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Cement is one of the most widely used building materials in the world, and for good reason. It's strong, durable, and versatile, making it the go-to choice for constructing everything from skyscrapers to sidewalks. But with climate change altering the weather patterns that concrete structures are exposed to, there are growing concerns about how these structures will hold up under increasingly extreme conditions.

Let's explore the potential impact of climate change on the durability and longevity of cement structures.

One of the most obvious ways in which climate change is affecting the weather patterns that concrete structures are exposed to is through more frequent and severe extreme weather events. From hurricanes to floods, these events can cause significant damage to buildings and infrastructure, including concrete structures. In many cases, the damage caused by these events can be catastrophic, leading to collapse or even complete failure of the structure.

One example of this is the recent floods in KwaZulu-Natal province in 2019, which caused extensive damage to buildings and infrastructure. The heavy rainfall and flooding resulted in collapsed bridges and roads, as well as damage to buildings and homes. Concrete structures, including buildings and retaining walls, were also impacted by the floods, as the prolonged exposure to water can weaken and wash away surrounding and base substrates (soil) which in turn may negatively affect the concrete element's structural integrity. This highlights the need for improved infrastructure planning and design that takes into account the potential impacts of climate change and extreme weather events.

Changes is Precipitation Patterns

Another way in which climate change is affecting concrete structures is through changes in precipitation patterns. As the climate warms, some areas are experiencing more frequent and intense rainfalls and these conditions can have an impact on the durability and longevity of concrete structures.

Care should be taken in higher rainfall areas to prevent ingress of moisture that may affect and deteriorate steel reinforcing which in turn could lead to spalling.

Rising Temperatures

Finally, rising temperatures are also having an impact on cement structures. As the climate warms, concrete is more susceptible to thermal expansion and contraction, which can cause cracking and other forms of damage. In addition, higher temperatures may increase the rate of evaporation, which in turn could lead to plastic shrinkage and or drying shrinkage cracks. Higher temperatures may also accelerate both open and setting times of concrete which in turn, could hamper the finishing process of concrete floors, plaster applications and shuttered applications to name a few.

What can be done?

As the impacts of climate change become more apparent, it's clear that concrete structures will need to adapt to the changing weather patterns they are exposed to. By using the right cement product and building materials, we can ensure that structures remain durable and resilient in the face of changing environmental conditions.

For expert advice on the correct cement products to achieve the best possible results, contact:
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When heat or cold complicates concrete – call Chryso

Extreme weather conditions make life difficult for contractors working with concrete – affecting both strength and open time. With the right admixture, though, these impacts can be controlled, explains CHRYSO Southern Africa's Technical Manager Patrick Flannigan.

When ambient temperatures become very hot or cold, concrete users can struggle to achieve the required strength and workability – but there are admixtures for those challenges.

Patrick Flannigan, Technical Manager at CHRYSO Southern Africa, explains that high temperatures cause concrete to develop higher initial strength, but reduce the strength development over the long term. Very cold weather creates the opposite effect, causing lower strength gain initially but higher strength gain later.

When temperatures drop below 5°C, the slower hydration process could even cause extended bleeding. At temperatures lower than that, there is a risk that the water in the concrete will freeze. Water expands by 9 % when it freezes, so it could even cause cracking if the concrete has not reached sufficient strength.

"To deal with very hot weather, customers use our CHRYSO® Tard range of plasticisers, which ensures enough open time," he says. "This retarder slows down the hydration of cement by momentarily blocking the surface of the cement particles and delaying the time of initial setting."

For cold weather, he recommends the CHRYSO® XEL range of chloride and non-chloride accelerators, which help with early strength gain of concrete. To deal with the risk of water freezing in the concrete, CHRYSO® Air helps by adding extra air to the mix. Instead of cracking the concrete, the freezing water will expand into the capillary openings that the air entrainer has created. These low temperatures are not that common in South Africa, but more relevant to higher elevated areas such as the Lesotho Highlands.

"Another form of extreme weather leading to challenges with concrete is heavy rainfall that causes flooding," he says. "Protection of concrete in rainy conditions is of the utmost importance, as this will eliminate surface blemishes on exposed concrete areas."

CHRYSO plasticisers allow a mix design to be optimised, giving more open time to the fresh concrete.

Flannigan explains that concrete that is in contact with standing or flowing water needs to be protected, especially in terms of its finish. "CHRYSO® Aquabeton is the ideal solution for concrete that needs to be placed underwater, and this allows concrete to be cast in standing or flowing water."

Flannigan points out that CHRYSO's solutions are driven not only by functionality but by a global commitment to sustainability. The company develops admixtures specially for certain types of cement and construction material. This allows a wider range of material to be sourced close to site, even if it is high in clay content, for example.

"This reduces the distances that material needs to be transported and therefore keeps vehicle carbon emissions to a minimum," he says. **CB**

Contact: www.za-chryso.com

Patrick Flannigan, Technical Manager at CHRYSO Southern Africa.

Kendal Ash Disposal Facility nears completion

Led by joint venture partners Concor and Lubocon Civils, the Kendal Ash Disposal Facility expansion project, responsible for the storage of ash produced by Kendal Power Station until 2023, has successfully reached over 80 % completion. With a projected completion date set for March 2024, this intricate venture is rapidly approaching its final stages.

The Kendal Ash Disposal Facility expansion project, responsible for the storage of ash produced by Kendal Power Station until 2023, has successfully reached over 80 % completion. With a projected completion date set for March 2024, this intricate venture is rapidly approaching its final stages.

Led by joint venture partners Concor and Lubocon Civils, the project accelerated its construction schedule over the winter, capitalising on the dry conditions. Concor's Project Manager, Pierre Jansen van Vuuren, highlights the stellar productivity in June and July when the teams committed to continuous 24-hour shifts to gain momentum before the onset of the rainy season.

Spanning a massive area of 2.5 km by 3 km, the project's components comprise the new 65 hectare Ash Disposal Facility (ADF), two dams each for both clean and polluted water storage, silt traps, an expansive 16 km V-drain system, a significant stream diversion and access road construction.

While the stream diversion and majority of the 14 km access roads have been completed, the principal focus now revolves around the ADF and the basins.

The in-situ material is clay soils which calls for a specific construction methodology. Selected stockpiled excavated materials are being used in a double-layered low permeability clay for base protection, topped with carefully selected river sand to prevent liner damage. Cutting-edge drainage and leachate collection systems are incorporated to manage water flow efficiently, emphasising sustainability with dirty water reuse for dust suppression and other ADF activities.

Concor's innovative approach in basin construction employs a patented PVC concrete formwork system, boosting efficiency by accelerating the casting panel process. This technique is not only time saving but also labour efficient.

Jansen van Vuuren accentuates the rigorous quality control measures in place. Leak prevention is paramount, with electronic leak detection ensuring construction integrity.

The expansion of the Kendal Ash Disposal Facility is more than 80% complete.

The Kendal Ash Disposal Facility has a project footprint that extends some 2,5 km by 3 km.

"Our teams maintain open communication, emphasising the importance of the quality and structural integrity of the project," he adds.

Challenges notwithstanding, the project is gearing up to finalise the liner system installation before the rainy season, with subcontractor Aquatan managing the basins and the ADF concurrently.

Highlighting the human element, Jansen van Vuuren praises the skilled workforce, noting that 852 locals have received training, and the project's local procurement achievement stands at a remarkable 55 %.

He says this involvement extends beyond labour, and is aligned with Eskom and the Joint Venture's CSI strategies, which are aimed at giving back to the local communities. By identifying local community recipients and working together with the contractors on its projects, Eskom ensures that the upliftment is extended beyond just employment opportunities.

A good example associated with the Kendal Ash Dump Facility project was the adding of modular classrooms using containers and the fitting out of a kitchen at a local primary school, by the Joint Venture in conjunction with Eskom. This opportunity to give back addresses other needs within the community such as education and nutrition. **CB**

Contact: www.concor.co.za
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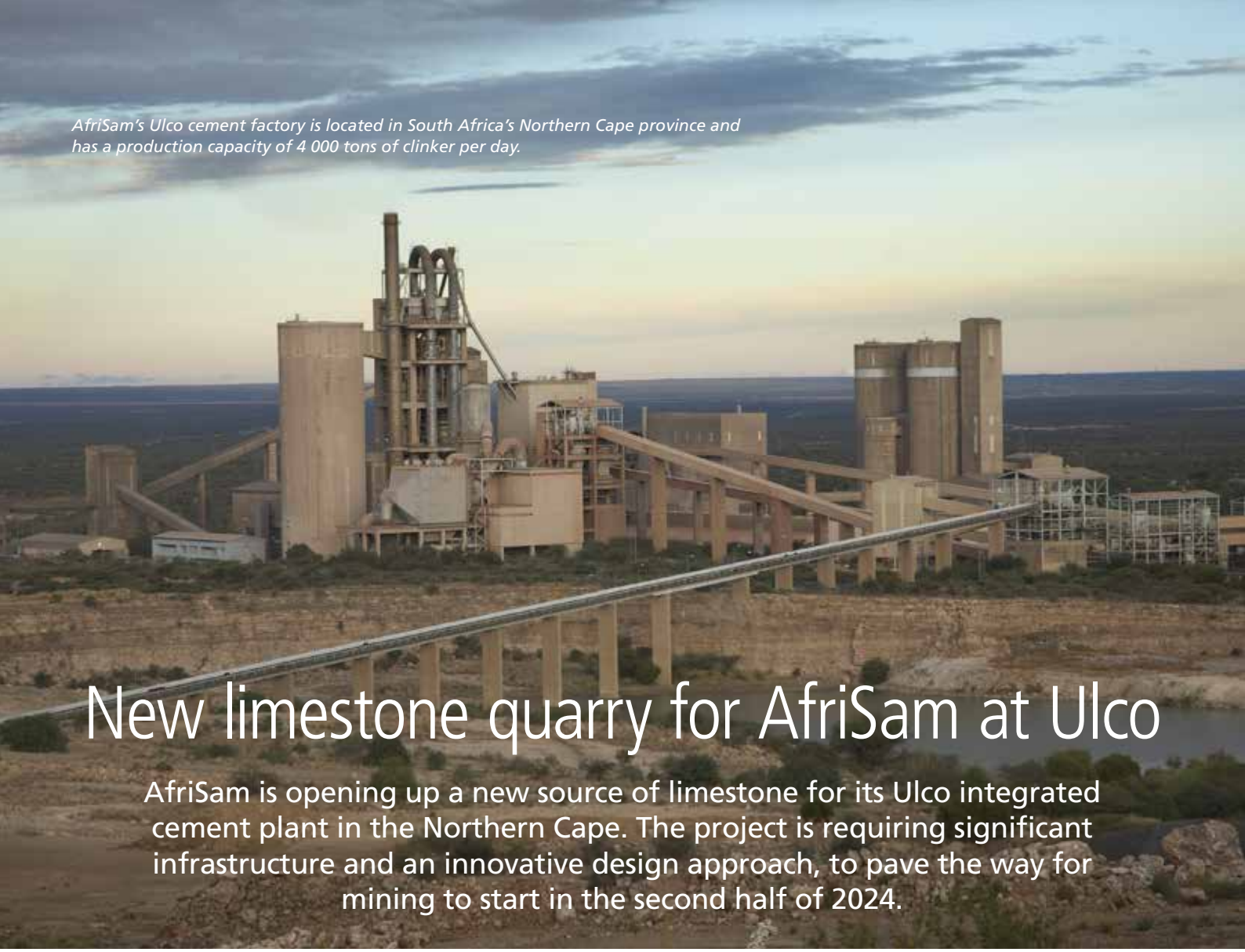
Two HDPE lined earth dams which hold clean water while two similar dams will hold polluted water.

Pierre van Vuuren, Concor Project Manager.



AfriSam's Ulco cement factory is located in South Africa's Northern Cape province and has a production capacity of 4 000 tons of clinker per day.

New limestone quarry for AfriSam at Ulco

AfriSam is opening up a new source of limestone for its Ulco integrated cement plant in the Northern Cape. The project is requiring significant infrastructure and an innovative design approach, to pave the way for mining to start in the second half of 2024.

Existing Ulco operation with new mining area outlined in red.

As the important mineral component of its cement, limestone will soon be mined from a new deposit by AfriSam's Ulco cement plant in the Northern Cape.

The relocated quarry will be capable of providing security of supply for about 40 years, and will need to deliver around two million tons of limestone to Ulco each year. According to Gavin Venter, Manager Saldanha and Strategic Projects at AfriSam, the enabling infrastructure for this quarry has been significant.

"After conducting a number of wide-spaced prospecting campaigns – as well as close-spaced drilling across 100 hectares – we identified the best limestone reserves on our mining right on the opposite side of the R31 national road, which runs between the new site and the plant," says Venter. "This means it is necessary to construct tunnels under the road to facilitate safe access between the new quarry site and the existing plant. Adding to the complexity is that the large Gamagara water pipeline runs parallel to the road."

The R31 road between Kimberley and Postmasburg carries high volumes of large ore trucks and abnormal load mining equipment. It will be diverted in early 2024 to accommodate

this traffic for about six months while extensive excavation and civil engineering work is undertaken to construct the tunnel underpass system.

"In compliance with the road authority's requirements, the tunnels will traverse the full 32 metre width of the road reserve – to allow for future road widening, in addition to the pipeline servitude," he says. "The two tunnels themselves will be over 50 metres in length, and will be separated to enhance safety as there will be counterflow traffic to and from the plant."

The 5 metre high by 5 metre wide tunnels will be excavated to 12 metres below the R31 road level, and constructed as large culverts with steel reinforced in-situ cast concrete. The design work ensured a tunnel alignment to suit the future possibility of an in-pit crusher and conveyer belt. If such an option was financially justified in future, it would provide an alternative method to feed crushed material to the existing pre-blending stockpiles.

The civils works also has to accommodate the 700 mm diameter Gamagara pipeline, supplying the Northern Cape with water from the Vaal River. To avoid the risk of disrupting this water supply, a concrete bridge has been constructed parallel to the existing pipeline, inside which a new 100 metre stretch of pipeline was laid.

"This provided the necessary support for the pipeline so that excavation and controlled blasting can be conducted underneath," he explains. "As a further precaution, there is also a 100 mm per second vibration limit applied to any blasting activity around the pipeline bridge."

Work on the pipe bridge began in late 2022 and excavation work began in the third quarter of 2023, creating the initial slot on the south side of the R31. Once the road is diverted, the excavation of the tunnels can begin and this is expected to be complete by end February 2024. This will be followed by the construction of the two tunnels. The supply of readymix – which will include AfriSam cement – will come from Kimberley, about 80 km south. With ambient daytime temperatures that can rise to 40 degrees, this will require careful use of admixtures to achieve the required slump by the time readymix trucks arrive on site.

"Mining is expected to begin in the second half of 2024, with an unusual topography in which the quarry will be mined into an escarpment," says Hannes Meyer, Cementitious Executive at AfriSam.

Ulco project area showing the development of the R31 bypass and drainage line diversion above it.

"Transportation of mined material is therefore mainly downhill. With the gradient of the haul road slopes limited to 5 degrees, AfriSam's truck-trailer combinations have been designed to be much more energy efficient than conventional off-road dump trucks."

AfriSam commissioned various specialist studies as part of its environmental impact assessment (EIA), to investigate the new quarry's potential effects on wetlands, terrestrial life, hydrology, heritage and traffic. Authorisation was granted to mine in the vicinity of water features on the proposed mining area, with a seasonal drainage line that had to be diverted to avoid the exit slot of the new haul road.**CB**

Contact: www.afrisam.com

Hannes Meyer, AfriSam Cementitious Executive.

Gavin Venter, AfriSam Manager Saldanha & Strategic Projects

Robots and automation are key trends in the demolition industry

Demolition robots are a relatively new form of professional service robot used in the demolition sector to demolish buildings at the end of their lifecycle. These mobile robots leverage a range of end-of-arm tools such as breakers, crushers, drills, or buckets to break through building materials.

Allied to this is the fact that demolition technology is advancing globally, which is having a positive impact on the local sector. While demolition robots and remote demolition have been available for many years, there are limitations to the technology. For example, Jet Demolition has remote-control units that can be fitted to its plant.

"This type of technology is used specifically where there is a risk of soil subsidence during sinkhole remediation. The machine operator is able to control the machine from a distance. However, there is a definite compromise on precision and reactivity," says Kate Bester, Contracts and Project Manager at Jet Demolition.

A crusher from Jet Demolition suspended from a crane to crush concrete silo walls.

"For the most part, being able to read and assess a structure's behaviour is paramount to the safety of the team, which is very difficult to do from a distance. For this reason, our use of remote-demolition practices is very restricted," highlights Bester. Oftentimes, remote-controlled techniques are reserved for instances where it simply is not practically possible to approach a structure safely using conventional demolition techniques, and a considered decision is made to approach the structure remotely, in the interest of safety.

Most demolition robots resemble small excavators, minus the cab. They are designed to function effectively in constrained spaces and fit through doorways and stairways, for example. Demolition robots occupy 90 % of the total market for construction robots.

In addition, they are one of the first commercially viable service robots to tackle applications in a traditionally labour-intensive industry. The value of the overall construction robot market was anticipated to be $321 million in 2022, with a global compound annual growth rate (CAGR) of 8.7 % from 2016 to 2022.

In addition to demolition robots, autonomous mobile robots (AMRs) are one of the latest and most innovative automation solutions available. AMRs differ from automated guided vehicles (AGVs) by their degree of autonomy, with AMRs far more independent and adaptable than AGVs. They can navigate complex environments and avoid obstacles without the need for external guidance systems.

"Automating demolition is all about safety and efficiency," says Bester, adding that it also has the potential to reduce cost for both demolition and construction companies. Robotic automation places human workers out of harm's way and allows them to be more productive. While the initial capex is high due to it being a relatively new technology, the long-term return on investment and impact on health and safety more than offsets the initial cost, notes Bester.

A mechanical pulveriser from Jet Demolition used to crush concrete on site.

"Our main concern is for the safety of people. Our methods, resources, and approach are all aligned exactly to serve this purpose. We have been in business since 1994 and have kept our focus on the main objective of completing a project safely, on time, and to international standards," says Bester.

While Jet Demolition undertakes most types of demolition work, its preference is generally for a mechanical application as a 'best possible' approach. This is in accordance with international best practice of separating workers from risk. Jet Demolition has an extensive equipment fleet, giving it the flexibility to draw from within its own reserves to suit the method selected.

Plant is kept in top condition by an in-house team of mechanics. It is generally traded in at low hours, generally much sooner than typical in the construction industry. Plant is ready, in good working order, and always available for the next project, concludes Bester. **CB**

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Email: kate@jetdemolition.co.za
Web: www.jetdemolition.co.za

Contracts and Project Manager Kate Bester.

ABOUT JET DEMOLITION

Jet Demolition has been undertaking industrial demolition works since 1994, and is the leading, largest, and most technically advanced demolition company in Africa. It offers in-house, full-range demolition services, including advanced mechanical solutions and controlled implosions. It actively pursues ongoing development of skills and equipment suited to the changing needs of the industry.

Jet Demolition is a technically based company, with various staff members holding MSc, BSc, and BTech Degrees, as well as National Diplomas, in various engineering fields. This expertise gives it the technical foundation to successfully engineer solutions for large and complex demolition projects, and furthermore fuels its drive to deliver quality projects safely. Jet Demolition strives to offer its clients innovative and technical solutions to demanding demolition challenges.

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SCP P3 wins prestigious concrete technology award

Spray-Lock Concrete Protection's unique SCP P3 Industrial technology won the prestigious World of Concrete's 2024 People's Choice Innovative Product Award in the Concrete Repair & Demolition Materials, Tools & Equipment category.

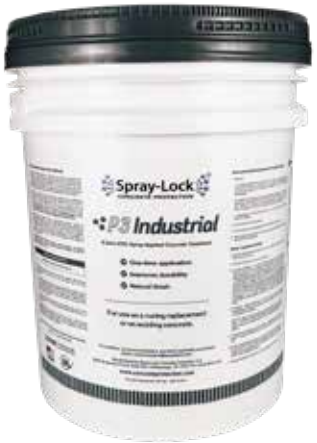
Patrick Flannigan, Technical Manager at Now in its second year, The People's Choice Innovative Product Award, held alongside World of Concrete in Las Vegas, United States, celebrates the most impressive innovations in concrete equipment, materials, services and tools across eight categories. It is presented to one winner in each programme category. Industry professionals who attended World of Concrete and the audience of the digital edition, WOC360, were invited to vote for what they believed to be the most innovative product. Voting opened in early January and ended on February 9, 2024.

Spray-Lock Concrete Protection's colloidal silica post-placement pozzolan (P3) technology is the most effective base-waterproofing product on the market, significantly increasing the durability of concrete and, therefore, prolonging the overall service life of concrete structures.

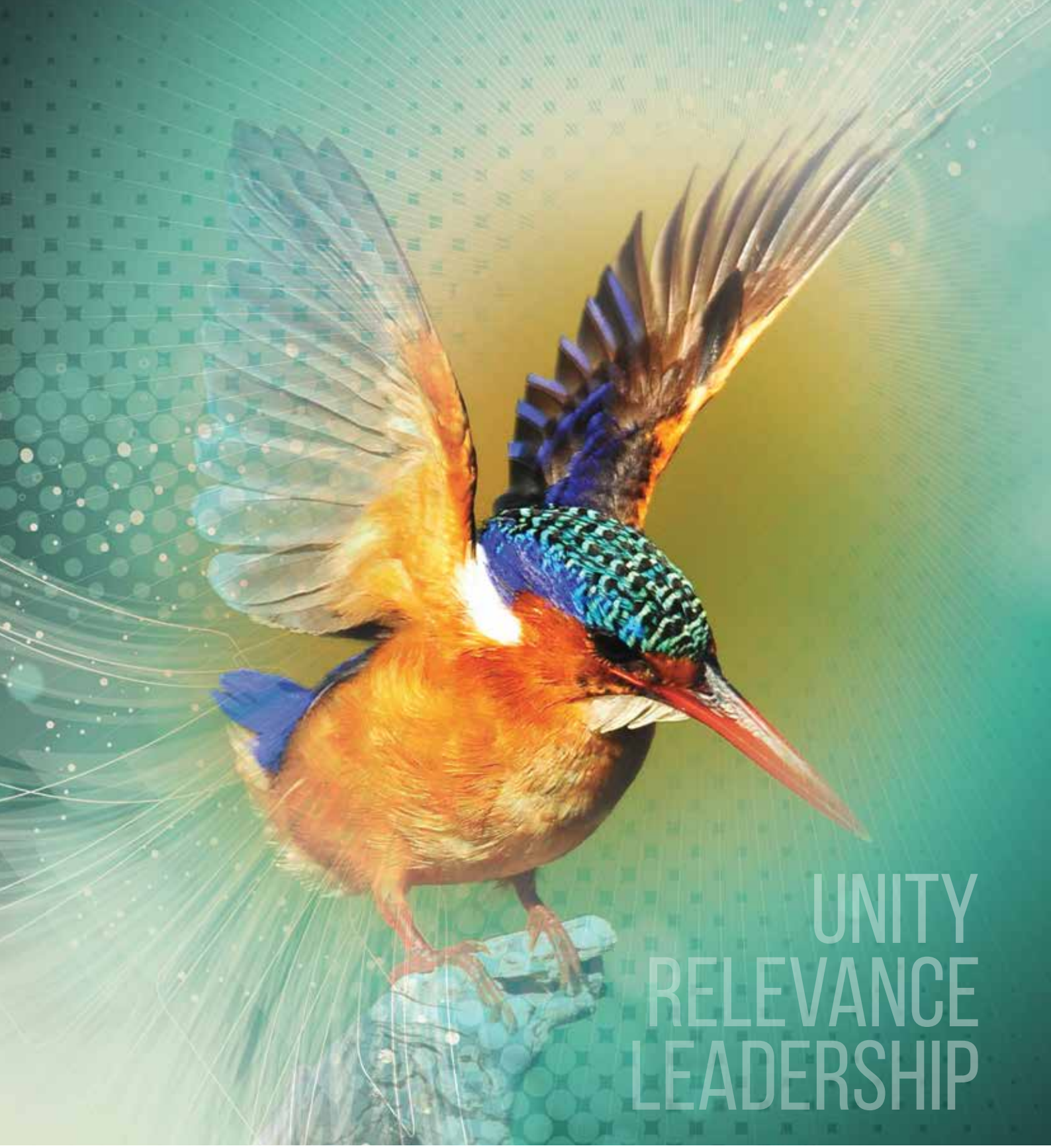
Unlike membrane products that are temporary and only partially functional if applied correctly, SCP technology permanently waterproofs "green" (less than 24-hour-old) concrete and existing (older than 24-hour-old) concrete after a single spray application.

Slabs can be accessed within an hour after treatment with SCP P3 Industrial. There is no wait time involved or need to re-mobilise just to apply a sealant.

World of Concrete is the biggest annual international event dedicated to the commercial concrete and masonry construction industries. This year's event was the 50th edition, attracting nearly 60 000 registered professionals from various sectors of the built-environment industry. **CB**



SCP permanently waterproofs "green" concrete and existing concrete after a single spray application.concrete equipment, materials, services and tools.



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Wolf wind farm project advances swiftly with Concor

Construction of the first half of the concrete access road up the 18% incline towards the top of the mountain to ensure safe access for the turbine components.

With a growing list of successfully executed renewable energy projects under its belt, Concor is almost halfway through another exciting wind farm development. Located near Jansenville in the Eastern Cape, the Wolf Wind Farm will contribute 84 MW of clean energy into South Africa's grid from 2025.

Work is progressing well on the Wolf Wind Farm in South Africa's Eastern Cape province, with Concor carrying out the civils balance of plant – including an innovative design for a steeply inclined concrete road to the site.

The contract, which is being tackled in a consortium with Murray & Roberts company OptiPower for developer Red Rocket, will see Concor building 17 foundation bases for wind turbine generators on a ridge in the Klein Winterhoek mountain range. Concor Contracts Manager and Lead Project Manager for the consortium, Stephan Nel, explains that the bases are for two sizes of turbine: there will be five 6,2 MW Vestas V162 turbines – the largest in South Africa – and twelve 4,5 MW V163 models.

Bulk earthworks and rock excavation underway on the Wolf Wind Farm project.

"The foundation bases for V162 turbines measure 22,5 m in diameter, while the V163 foundations are 21,2 m," says Nel. "The larger bases will consume over 650 m^3 of concrete each, with the slightly smaller bases taking almost 600 m^3."

Concor is conducting over 180 000 m^3 of bulk earthworks for the base excavations and roadways on site – which includes 15 km of access road to reach the 17 wind turbines. A total of 100 000 m^3 of rock will be blasted during the construction of the project. After cleaning, a concrete lining is applied and specially designed anchor cages of steel reinforcing bar – weighing either 64 t or 70 t dependent on the base size – are installed.

Concrete from the batch plant at the foot of the ridge will – like all other wind turbine components and related equipment – have to

Construction and installation of the earthmat on the IPP substation for the Wolf Wind Farm project.

The variance in rock formation is visible in the foundation excavations.

traverse a steep 18 % incline gradient to reach the top of the ridge where the turbines will be located. He highlights that this challenge required an innovative solution that could be rapidly executed.

"In collaboration with the client, consultants and specialist service providers, we designed a concrete roadway that could be constructed using the slipform method," he says. "The 1,100 m roadway, measuring 7 m wide, was completed in January this year, paving the way for the on-schedule execution of the project."

Among the challenges in the road construction was designing a concrete mix with a 35 slump – to prevent the poured concrete from moving on the slope – that would still be workable for the required window period. Nel notes that high daytime temperatures of 36° C and above aggravated this issue further.

"After considerable planning, investigation and trialling, a solution was developed to allow the slipform paver and the cement trucks to operate on the steep incline, and to lay down the concrete road as planned," says Nel. "The road was continuously poured at an advance rate of about 200 m a day, consuming some 1,600 m³ of concrete – reinforced with anchor beams and intermittent steel bars." **CB**

Contact: www.concor.co.za

Medium Voltage (MV) cable trenching in progress tying into the foundations

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